Keywords in "Mechanical Universe and Beyond" Videos—C.E. Mungan, Spring 2001

This entire series can be viewed online at http://www.ctl.ua.edu/Video/ctlisgreat/muab.htm.
Some of the titles below have been modified by me to better reflect their contents.
In my opinion, tapes 21–22 are the best in the whole series!

1. Introduction to Classical Mechanics: Kepler, Galileo, Newton
2. Falling Bodies: $s = gt^2/2, \quad v = gt, \quad a = g$
3. Differentiation: introductory math
4. Inertia: Newton's first law, Copernican solar system
5. Vectors: quaternions, unit vectors, dot and cross products
6. Newton's Laws: Newton's second law, momentum, Newton's third law, monkey-gun demo
7. Integration: Newton vs. Leibniz, anti-derivatives
8. Gravity: planetary orbits, universal law of gravity, the Moon falls toward the Earth
9. UCM: Ptolemaic solar system, centripetal acceleration and force
10. Fundamental Forces: Cavendish experiment, Franklin, unified theory, viscosity, tandem accelerator
11. Gravity and E&M: fundamental constants, speed of light, Oersted experiment, Maxwell
12. Millikan Experiment: CRT, scientific method
13. Energy Conservation: work, gravitational PE, KE, mechanical energy, heat, Joule, microscopic forms of energy, useful available energy
14. PE: stability, conservation, position dependence, escape speed
15. Conservation of Linear Momentum: Descartes, generalized Newton's second law, Earth-Moon system, linear accelerator
16. SHM: amplitude-independent period of pendulum, timekeeping, restoring force, connection to UCM, elastic PE
17. Resonance: Tacoma Narrows, music, breaking wineglass demo, earthquakes, Aeolian harp, vortex shedding
18. Waves: shock waves, speed of sound, coupled oscillators, wave properties, gravity waves, isothermal vs. adiabatic bulk modulus
19. Conservation of Angular Momentum: Kepler's second law, vortices, torque, Brahe
20. Precession: gyroscopic stability, equinoxal drift
21. Kepler's Laws: Mars, properties of ellipses
22. Kepler Problem: astronomical bodies moving along conic sections
23. Orbital Energy: shapes of orbits, telescopes
24. Spacecraft: satellites, transfer orbit, gravity assist
25. Gravity: tides, Kepler's third law, inertial vs. gravitational mass (Principle of Equivalence), spacetime curvature, black holes
26. Review of Classical Mechanics: summary of tapes 1–25
27. Introduction to Modern Physics: Levi-Civita tensors, Einstein, Franklin, Faraday, Maxwell, Volta, Tesla, Edison, Michelson, thermodynamics, SR, QM

28. Static Charge: Coulomb, fluid model of electricity, charging by induction, Leyden jars, Wimshurst machine
29. Electric Field: Faraday, flux, Davy, Gauss' law, Faraday cage
30. Capacitance: Leyden jars, Franklin, equipotentials, lightning rods
31. Voltage: comparison to gravitational PE, relation to electric field, dipole, conductors, lighting, power grid, atomic binding, plasmas, atomic chemistry
32. Batteries: Volta, Galvani, work function, electrophorus, role of electrolyte
33. Circuits: Wheatstone, current, conservation of charge, Ohm's law, resistivity, series vs. parallel, analogy between resistivity and viscosity, power, Kirchhoff's laws, RC circuit
34. Magnetism: Gilbert, geomagnetism, auroras, temperature dependence, poles, monopoles, dipolar field, solar wind, flux and Gauss' law, geomagnetic reversal, sunspots, Lorentz force, Peregrinas
35. Magnetic Field: Ampère, wire/loop/solenoid/toroid, Ampère's law, Maxwell's equations
36. Vector Fields: hydrodynamics, flux, circulation, field energy density, vortex cannon demo
37. Induction: Faraday's law, emf, Edison dc vs. Tesla ac, Lenz's law, alternative energy sources, inductors, mutual inductance demo, magnetic brake demo, jumping ring demo
38. AC: generators, Tesla ac vs. Edison dc, LC/RC/LRC resonance and mechanical analog, Westinghouse, step up/down transformers for electric transmission
39. Maxwell's Equations: Maxwell, oscillating fields, speed of light, displacement current
40. Optics: wave properties, refraction, dispersion, Huygens, spectra, Young interference experiment, Fermat's Principle of Least Time, lenses and mirrors, optical instruments, ether
41. Michelson-Morley Experiment: ether, Lorentz transformations, Fitzgerald, Poincaré, Einstein
42. Lorentz Transformation: invariance of speed of light, relativity of simultaneity, time dilation, gamma factor, length contraction, Einstein's postulates, spacetime diagram and events, light cone
43. Historical Development of SR: transformation between electric and magnetic fields, relativity of simultaneity, time dilation, velocity addition on a spacetime diagram, cosmic ray muon experiment, twin paradox
44. Relativistic Momentum and Energy: momentum conservation requires speed-dependent mass, relativistic energy $E = mc^2$
45. Gas Laws: temperature, heat, thermometer, pressure, molecular dynamics simulations, kinetic theory, Boyle, Boyle's law, Charles, Gay-Lussac, absolute zero, Kelvin, ideal gas law, Fahrenheit and Romer
46. Engines: Carnot, steam engines, Watt, cylinders, efficiency, Caloric fluid model of heat, second law of thermodynamics, refrigerators, reversibility, isothermal and adiabatic processes, internal energy, Clausius, entropy
47. Entropy: four laws of thermodynamics, constant temperature of melting ice, thermal equilibrium, heat flows from hot to cold, collective vs. internal energy, Carnot cycle, Clausius, Kelvin, real engines create entropy while ideal engines conserve it, equilibrium is a state of maximum entropy, free energy, heat death of the universe, arrow of time, microscopic reversibility vs. macroscopic irreversibility

48. Low Temperatures: phases, *p*-*T* diagram, critical point, Faraday, cooling by evaporation, dry ice, cascade cooling, heat exchanger, mechanical equivalent of heat, Joule-Thomson free expansion, von Linde, Onnes, Dewar, liquid helium
49. Atom: Bohr model, Dalton's Law of Proportions, Avogadro's number, diffusion, Balmer line spectra, Rydberg constant, Thomson plum-pudding model, Rutherford scattering from nucleus, Planck energy quantization, quantization of angular momentum, quantum jumps, scientific model building
50. QM: blackbody radiation, photon energy, photoelectric effect, work function, de Broglie wavelength, angular momentum quantization, two-slit diffraction, Schrödinger wave mechanics, Born probabilities, HUP, wave vs. photon interpretation of demo inserting a third polaroid between two crossed ones
51. Particles: scientific theories, particle accelerators, Fermilab, Bohr model, QM, HUP, quantum numbers, orbitals, spin, PEP, periodic table, elementary particles, quarks, nondeterminism
52. Conclusions: QM vs. GR, main goals of physics are abstractions/approximations/essentials, grand summary, revolutions in physics